Class	Adm No

Candidate Name: ____________________

H

millennia institute

2024 Mid-Year Examination
Pre-University 3

H2 CHEMISTRY **9729/04**

Paper 4 Practical **25 June 2024**

2 hours 30 minutes

Candidates answer on the Question paper.

READ THESE INSTRUCTIONS FIRST

Do not turn over this question paper until you are told to do so.

Write your name, class and admission number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
Qualitative Analysis Notes are printed on pages 17 and 18.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Question	1	2	3	4	**Total**
Marks	15	13	12	15	**55**

Answer **all** the questions in the spaces provided.

1 Determination of the concentration of a glucose solution using a graphical method

Glucose in solution reduces purple, acidified potassium manganate(VII) solution, **FA 3**, to a colourless or slightly yellow solution at end-point.

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

In this experiment, the rate of this reaction is studied by measuring the time taken for the reaction mixture to reach the end-point.

You will perform a series of five experiments. Then you will graphically analyse your results to determine the order of reaction with respect to the concentration of glucose.

For each experiment, you will note the time taken, *t*, for the reaction mixture to reach end-point. You will then calculate values of 1/t and record them to an appropriate level of precision.

The experiment is then repeated using a solution of glucose of unknown concentration. By comparing the time taken for the reaction mixture to reach the end-point with the graph, the concentration of glucose in the unknown solution can be determined.

FA 1 is 20% by mass of glucose solution.
(i.e. there is 20 g of glucose in 100 cm^3 of water)
FA 2 is 1 mol dm^{-3} sulfuric acid, H_2SO_4.
FA 3 is 0.0025 mol dm^{-3} potassium manganate(VII), $KMnO_4$.
FA 4 is a sample of glucose solution that has concentration between 30-40%.

Experiment	volume of **FA 1** /cm^3	volume of water /cm^3	% glucose in solution **X**	*t* /s	1/*t* /s^{-1}
1	10.0	0.0	20%	35	0.0286
2	8.0	2.0	16%	46	0.0217
3	6.0	4.0	12%	57	0.0175
4	4.0	6.0	8%	81	0.0123
5	2.0	8.0	4%	135	0.00741

Table 1.1

(a) Varying volumes of water are added to **FA 1** to form 10 cm^3 of solution **X**, which contains different concentrations of glucose. State the volume of water to be added for each experiment in Table 1.1 above.

[1]

1m for all correct volumes of water

(b) Explain why the total volume of solution **X** needs to be kept constant for all experiments. [1]

This is so that the **concentration of FA 1** in the experiment will be **proportional to the volume of FA 1 used**.

Candidate must include volume of FA1, cannot just say proportional to the volume.

(c) **Experiment 1**

1. Add 10 cm^3 of **FA 1** into a boiling tube using a measuring cylinder.
2. Add 5 cm^3 of **FA 2** into the same boiling tube using the second measuring cylinder.
3. Swirl the mixture to mix well.
4. Add 2 cm^3 of **FA 3** using the third measuring cylinder and start the stopwatch.
5. Swirl the mixture gently and continuously until the purple colour is discharged.
6. When the purple colour is discharged, stop the stopwatch and record the time to the nearest second in Table 1.1 on page **2**.
7. Discard the reaction mixture immediately down the sink. Wash out the boiling tube and stand it upside down on the rack to drain.

Experiment 2

1. Add 8 cm^3 of **FA 1** into another boiling tube using a measuring cylinder.
2. Add the volume of water you stated in Table 1.1 using the same measuring cylinder.
3. Add 5 cm^3 of **FA 2** into the boiling tube using the second measuring cylinder.
4. Swirl the mixture to mix well.
5. Add 2 cm^3 of **FA 3** using the third measuring cylinder and start the stopwatch.
6. Swirl the mixture gently until the purple colour is discharged.
7. When the purple colour is discharged, stop the stopwatch and record the time to the nearest second in Table 1.1 on page **2**.
8. Discard the reaction mixture immediately down the sink. Wash out the boiling tube and stand it upside down on a rack to drain.

Repeat the procedure above for experiments **3**–**5.**

You should alternate the use of the two boiling tubes provided.

(d) Plot a graph of 1/*t* on the *y*-axis against % of glucose on the *x*-axis on the grid in Fig 1.1.

Draw the best fit line taking account all of your plotted points.

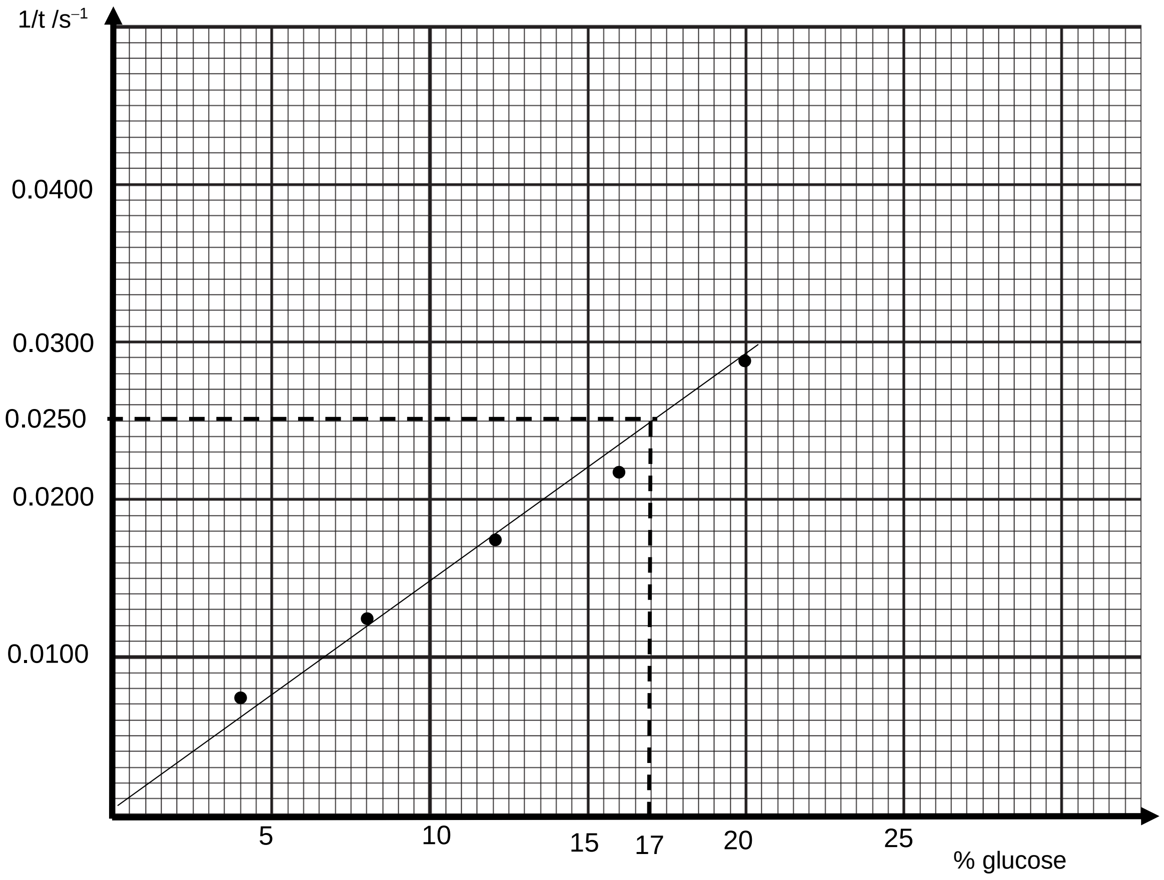

Fig. 1.1 [4]

1m completed Table 1.1 (5 readings)
1m Table 1.1 to correct precision (t to nearest second, 1/t to 3sf)
1m axis with units, appropriate scale (more than 50% of plot area occupied)
1m points plotted correctly + best fit line drawn (shape not penalised)

(e) Explain why the rate of reaction is proportional to 1/*t*. [1]

A fixed amount of purple $KMnO_4$ is used for each experiment. Since the time taken is for a fixed amount of purple $KMnO_4$ to disappear, rate of reaction is proportional to 1/time.

(f) Use your graph to deduce the order of reaction with respect to glucose.

Since a straight line is obtained, rate of reaction is directly proportional to concentration of glucose [1].
Thus order of reaction is first order [1] with respect to glucose.
1m traight line + rate proportional to conc of glucose
1m conclude first order (must be substantiated)

order of reaction with respect to glucose = 1 [2]

(g) You are to dilute **FA 4** by half by mixing 5 cm^3 of **FA 4** with 5 cm^3 of water as in Table 1.2 below before conducting the experiment.

Table 1.2

Experiment	volume of **FA 4** /cm^3	volume of water /cm^3	t /s	1/*t* /s^{-1}
6	5.0	5.0	40	0.0250

Explain why it is necessary to dilute **FA 4** by half before conducting the experiment. [1]

The concentration of glucose in **FA 4** is too high and is beyond the plotted points on the graph. An extrapolation of the best-fit line has to be made, and values obtained from this extrapolation will not be as accurate.

OR

The concentration of glucose is too high in **FA 4**, hence the time would be too short, leading to a high % error in the time measurement.

(h) Carry out your experiment according to the procedure in Experiment 2 and record your results in Table 1.2.

Use the graph to determine the % of glucose in **FA 4.** You are required to show your working on the graph and calculations clearly.

From the graph, when 1/t is 0.0250, % of glucose is 17%

Hence % of glucose in **FA 4** = 17.0 x 2 = 34.0%

1m results in Table 1.2
1m use of graph with construction lines to obtain % of glucose
1m multiply by 2 to obtain % glucose in **FA 4**

% glucose in **FA 4** = 34.0% [3]

(i) When you performed the experiments in **1(c)**, you were instructed to wash and drain the boiling tube before using it again.

State and explain the likely effect on *t* of **not** draining the boiling tube before it is reused.

effect on *t* increase [1]

explanation residual water will dilute the reactants, lowering their concentrations and hence increase *t* [1]
Must include lowering. Cannot just mention concentration is affected.

[2]

[Total: 15]

2 Determination of the value of x in the formula given for the oxoanion of iodine

IO_x^- is an oxoanion of iodine. It reacts with an excess of iodide ions, I^-, in an acidic medium to form iodine, I_2, and water.

The equation for this reaction is:

$$IO_x^-(aq) + \mathbf{a}\,I^-(aq) + (1 + \mathbf{a})\,H^+(aq) \rightarrow \left(\frac{1+\mathbf{a}}{2}\right) I_2(aq) + \left(\frac{1+\mathbf{a}}{2}\right) H_2O(l)$$

where **x** and **a** are all integers.

This amount of iodine produced can be analysed through a titration with sodium thiosulfate, $Na_2S_2O_3$.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

In this experiment, you are to prepare a standard solution of sodium thiosulfate and determine the formula of the ion, IO_x^-, by titration.

FA 5 is solid hydrated sodium thiosulfate, $Na_2S_2O_3.5H_2O$,
FA 6 is 0.00825 mol dm^{-3} IO_x^- ions,
FA 7 is 0.25 mol dm^{-3} aqueous potassium iodide, KI,
FA 2 is 1 mol dm^{-3} sulfuric acid, H_2SO_4 (from **Question 1**)
starch solution.

(a) Preparation of a standard solution of sodium thiosulfate

Procedure

1. Using a mass balance, weigh out accurately 3.00 g of **FA 5** into a weighing bottle.
2. Dissolve **FA 5** in about 50 cm^3 of deionised water in a 100 cm^3 beaker.
3. Transfer the solution and washings to a 250 cm^3 volumetric flask, using a filter funnel.
4. Top up to the 250 cm^3 mark with deionised water using a dropper when near the mark.
5. Stopper the flask and shake to ensure the solution is homogeneous. Label this solution as **FA 8**.

Record your mass measurements in Table 2.1.

Table 2.1

mass of weighing bottle and **FA 5** / g	6.20
mass of empty weighing bottle / g	3.20
mass of **FA 5** used / g	3.00

[1]

1m for mass table with readings to 2 dp and mass used within 2.95-3.05 g

(b) **Titration between iodine and sodium thiosulfate**

Procedure

1. Fill a burette with **FA 8.**
2. Using a 25.0 cm^3 pipette, add 25.0 cm^3 of **FA 6** to a 250 cm^3 conical flask.
3. Using appropriate measuring cylinders, add 25 cm^3 of **FA 2** followed by 10 cm^3 of **FA 7** to the same conical flask and swirl quickly. The solution will turn brown as iodine is produced.
4. **Immediately** titrate the I_2 produced in the conical flask with **FA 8**. When a yellow colour is obtained, add about 1 cm^3 of starch solution. Continue to titrate carefully until the blue-black colour of the starch-iodine complex is discharged.
5. Repeat steps 2 to 4 until consistent results are obtained and record your results below.

Results

Titration Number			
Final burette reading / cm^3	25.60	32.10	
Initial burette reading / cm^3	0.00	6.50	
Volume of **FA 8** required / cm^3	25.60	25.60	

1m headers of table correctly filled with units
1m for 2 consistent readings and all readings to 2 dp

Accuracy:
Titre reading
$x \leq \pm 0.10$cm^3 2m
$\pm 0.10 < x \leq \pm 0.20$cm^3 1m

Teacher's value: 25.80 cm^3

[4]

(c) From your titration results, obtain a suitable volume of **FA 8,** $V_{\text{FA 8}}$, to be used in your calculations. Show clearly how you obtained this volume.

average titre = $\frac{25.60+25.60}{2}$ = 25.60 cm^3

1m correctly calculate average titre value

$V_{\text{FA 8}}$ = 25.60 cm^3 [1]

(d) Calculate the concentration of sodium thiosulfate in **FA 8** that you prepared in **2(a)**.

[A_r: Na, 23.0; S, 32.1; O, 16.0; H, 1.0]

concentration of $Na_2S_2O_3$ = mass used in **(a)**/248.2 ÷ 250/1000

concentration of $Na_2S_2O_3$ = 3.00/248.2 ÷ 250/1000 = 0.0483 mol dm^{-3}

concentration of $Na_2S_2O_3$ in **FA 8** = 0.0483 mol dm^{-3} [1]

(e) Use your answer to **2(c)** and the relevant equation given on page 6 to calculate the amount of iodine that formed when 25.0 cm^3 of **FA 6** reacted with 10 cm^3 of **FA 7**.

relevant equation: $I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

amount of I_2 formed = ½ x **(c)**/1000 x **(d)**

amount of $S_2O_3^{2-}$ reacted = 25.60/1000 x 0.48348 = 1.2377 x 10^{-3} mol

amount of I_2 that formed = 1.2377 x 10^{-3} ÷2 = 6.19 x 10^{-4} mol

amount of I_2 = 6.19 x 10^{-4} mol [1]

(f) Calculate the amount of IO_x^- ions in 25.0 cm^3 of **FA 6**.

amount of IO_x^- = 25/1000 x 0.00825 = 2.06 x 10^{-4} mol (fixed ans)

amount of IO_x^- ions = 2.06 x 10^{-4} mol [1]

(g) Use the ratio of your answers to **2(e)** and **2(f)** along with the relevant equation given on page 6 to calculate the value of **a**.

$$\frac{(e)}{(f)} = \frac{(1+a)}{2}$$

Solve for **a** and **a** must be an integer

By mol ratio: 1 mol of IO_X^- reacts with $\frac{1+a}{2}$ mol of I_2

2.06 x 10^{-4} mol of IO_X^- reacts with 2.06 x 10^{-4} x $(\frac{1+a}{2})$ mol of I_2

2.06 x 10^{-4} x $(\frac{1+a}{2})$ = 6.19 x10^{-4}

2.06 x 10^{-4} x $(\frac{1+a}{2})$ = 6.19 x10^{-4}

$(\frac{1+a}{2})$ = 3

1+ **a** = 6

a = 5

a = 5 [1]

(h) Use your value of **a** to determine the formula of the IO_x^- ion.

Sub a = 5 into equation
$IO_x^-(aq) + 5I^-(aq) + 6\,H^+(aq) \rightarrow 3\,I_2(aq) + 3H_2O(l)$

Since there are 3 O atoms on right hand side,

x = 3

Formula of IO_x^- is IO_3^-

$IO_4^- + 7I^- + 8H^+ \rightarrow 4I_2 + 4H_2O$
$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$
$IO_2^- + 3I^- + 4H^+ \rightarrow 2I_2 + 2H_2O$
$IO^- + I^- + 2H^+ \rightarrow I_2 + H_2O$
allow for ecf based on value of **a** in **(g)**

formula = IO_3^- [1]

(i) The maximum error in the volume of **FA 6** dispensed by the 25.0 cm^3 pipette is ±0.06 cm^3.

Calculate the percentage error in the volume of **FA 6** used.

percentage error = (0.06/25) x 100% = 0.240% (fixed ans)

candidates need not put ± sign.

percentage error = 0.240 % [1]

(j) A student suggested that a more accurate value of **x** could be obtained if a 10.0 cm^3 pipette is used to measure **FA 7** rather than a measuring cylinder.

State whether you agree with the student. Explain your answer. [1]

No I disagree.
KI is used in excess so the precision of the instrument used to measure the volume is not important.

[Total: 13]

[Turn over

3 Identification of cations

At each stage of any test you are to record details of the following:

- colour changes seen;
- the formation of any precipitate;
- the solubility of such precipitates in an excess of the reagent added.

Where gases are released they should be identified by a test, described in the appropriate place in your observations.

You should indicate clearly at what stage in a test a change occurs.

No additional tests for ions present should be attempted.

Rinse and reuse test-tubes where possible.

(a) **FA 9** and **FA 10** are aqueous solutions that each have a cation from those listed in the Qualitative Analysis Notes.

You are also provided with the following:

- solid ammonium sulfate, $(NH_4)_2SO_4$
- aqueous hydrogen peroxide, H_2O_2

Carry out the following tests and record your observations in Table 3.1.

Table 3.1

	tests	observations
(i)	Add 1 cm depth of **FA 9** to a test-tube. Add aqueous sodium hydroxide slowly, with shaking until no further change is seen.	White ppt formed, insoluble in excess NaOH [1]
(ii)	Add 1 cm depth of **FA 9** to a test-tube. Add aqueous ammonia slowly, with shaking until no further change is seen. Keep this mixture for test **3(a)(iii)** later.	White ppt formed, insoluble in excess NH_3 [1]
(iii)	To the mixture from **3(a)(ii),** add two spatulas of ammonium sulfate and shake well.	Ammonium sulfate dissolves White ppt dissolves [1]

(iv)	Add 1 cm depth of **FA 10** to a test-tube. Add aqueous sodium hydroxide slowly, with shaking until no further change is seen.	Green ppt formed, insoluble in excess NaOH, turns brown on standing [1]
(v)	Add 1 cm depth of **FA 10** to a test-tube. Add aqueous hydrogen peroxide slowly with shaking until no further change is seen. Then add aqueous sodium hydroxide slowly with shaking until no further change is seen.	Solution turns yellow[1] Red brown ppt formed, insoluble in excess [1] Effervescence seen Gas evolved relights glowing splint Gas is O_2 [1]

[7]

(b) Identify the cation present in **FA 9** and **FA 10**.

The cation in **FA 9** is Mg^{2+}

The cation in **FA 10** is Fe^{2+}

[2]

(c) With the aid of equations, explain the observations in test **3(a)(iii)**. [2]

Ammonium sulfate dissolves completely in solution into its ions.

$NH_4^+ \rightleftharpoons NH_3 + H^+$
NH_4^+ is a weak acid and produces H^+, which reacts with / decreases concentration of OH^-.

$Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$ -------- (1)
The position of the equilibrium (1) shifts right when the concentration of OH^- is reduced, causing the ppt to dissolve.

1m NH_4^+ produces H^+ + reduce $[OH^-]$
1m eqm eqn + shift in POE

(d) Based on your observations in **3(a)(v)**, explain the role of hydrogen peroxide in the reaction. [1]

Oxidising agent, since it oxidises Fe^{2+} to Fe^{3+}, thus solution turns yellow.

[Total: 12]

4 Planning

The reaction between a carboxylic acid and alcohol to form an ester and water is a reversible reaction. This reaction proceeds at a very slow rate and thus a strong acid catalyst is added. Even with the use of the catalyst, the reaction must be left for **one week** to reach equilibrium.

$$RCO_2H + R'OH \rightleftharpoons RCO_2R' + H_2O$$

To determine the equilibrium constant, K_c, it is necessary to determine the amount of each species present in the equilibrium mixture.

Known amounts of a carboxylic acid, an alcohol and a dilute strong acid are mixed and stored in a sealed container. After sufficient time, the whole mixture is titrated against a standard solution of sodium hydroxide. This allows the total amount of acid in the mixture to be found.
This total amount of acid is made up of the strong acid and the carboxylic acid present in the equilibrium mixture.

The change in the amount of carboxylic acid present in the initial mixture and the equilibrium mixture can then be calculated. This can be used to deduce the amounts of each of the other components in the equilibrium mixture. With these data, a value of K_c may then be determined.

(a) A student decided to prepare a reaction mixture with 3.00 g of ethanoic acid, 3.00 g of methanol and 6.00 cm^3 of 1.00 mol dm^{-3} hydrochloric acid.

$$CH_3CO_2H + CH_3OH \rightleftharpoons CH_3CO_2CH_3 + H_2O$$

Data

compound	M_r	properties
ethanoic acid	60.0	corrosive
methanol	32.0	volatile, flammable, toxic
water	18.0	

Using the student's chosen amounts, write a plan on how the amounts of each component at equilibrium can be determined.

You may assume that you are provided with

- 1.0 mol dm^{-3} sodium hydroxide
- 5.0 mol dm^{-3} hydrochloric acid
- 10 g of liquid ethanoic acid
- 10 g methanol
- 100 cm^3 conical flask with stopper
- the equipment and materials normally found in the school laboratory

Your plan should include the following:

- an outline of how you would dilute the provided hydrochloric acid to the desired concentration,
- an outline of how the equilibrium reaction mixture can be obtained,
- practical details of how you would carry out the titration on the equilibrium reaction mixture.

Dilution of HCl

amount of HCl in 250cm^3 of 1 mol dm^{-3} HCl = 250/1000 x 1 = 0.250 mol
vol of 5 mol dm^{-3} HCl required = 0.250/(5/1000) = 50.0 cm^3

1m for calculating vol of 5 mol dm^{-3} HCl to use

1. Using a 50.00 cm^3 burette, transfer 50.00 cm^3 of 5 mol dm^{-3} HCl into a 250 cm^3 volumetric flask
2. Top up with deionised water to the 250 cm^3 mark.
3. Stopper and shake to obtain a homogeneous solution of 1 mol dm^{-3} HCl

1m use correct apparatus with capacity (burette and volumetric flask)
1m make to the mark with deionised water + stopper and shake

Preparing equilibrium reaction mixture

1. Using a mass balance, weigh out 3.00 g of ethanoic acid and 3.00 g of methanol into a 100 cm^3 conical flask.
2. Using a 50.00 cm^3 burette, transfer 6.00 cm^3 of 1.0 mol dm^{-3} HCl into the conical flask.
3. Stopper the conical flask and swirl to mix well. Leave the flask for one week to reach equilibrium.

1m use correct apparatus to measure out quantities (mass balance and burette)
1m stopper flask and leave for one week

Titration

1. Fill a 50.00 cm^3 burette with 1.00 mol dm^{-3} sodium hydroxide.
2. Take the reaction mixture flask and add 1-2 drops of thymolphthalein.
3. Titrate the contents of the reaction flask with NaOH from the burette. End point is reached when contents of flask turns from colourless to pale blue.
4. Record the volume of NaOH required for the titration.

1m use of burette (do not award this mark if student pipette out sample for titration)
1m use of indicator with correct colour at end point (thymol blue ok: yellow to green)

(b) The student prepared another two more conical flasks with the same masses of chemicals and recorded the results in a table.

	Flask 1	**Flask 2**	**Flask 3**
mass of methanol / g	3.00	3.00	3.00
mass of ethanoic acid / g	3.00	3.00	3.00
volume of hydrochloric acid / cm^3	6.00	6.00	6.00
final burette reading / cm^3	32.10	46.55	40.20
initial burette reading / cm^3	0.00	10.00	8.00
volume of sodium hydroxide used / cm^3	32.10	36.55	32.20
chosen values	√		√

Choose appropriate titration values by putting ticks below the values you chose and calculate the average titre for the student.

average titre = (32.10 + 32.20)/2 = 32.15 cm^3

average titre = 32.15 cm^3 [1]

(c) Calculate the amounts of all the components in the initial reaction mixture.

i) methanol
ii) ethanoic acid
iii) water
(For the purposes of this calculation, you may assume that 1.00 cm^3 of hydrochloric acid contains 1.00 cm^3 of water and that the density of water is 1 g cm^{-3})

initial amount of methanol = 3/32.0 = 0.0938 mol [1]

initial amount of ethanoic acid = 3/60.0 = 0.0500 mol [1]

initial amount of H_2O = 6.00 x 1/ 18 = 0.333 mol [1]

initial amount of methanol = 0.0938 mol

initial amount of ethanoic acid = 0.0500 mol

initial amount of water = 0.333 mol [3]

(d) Calculate the amount of ethanoic acid present in the mixture at equilibrium.

amount of NaOH reacted = 32.15/1000 x 1.00 = 0.03215 mol

amount of HCl present at equilibrium = 6/1000 x 1.00 = 0.00600 mol

amount of ethanoic acid present in the mixture at equilibrium
= 0.03215 – 0.00600
= 0.0262 mol

amount of ethanoic acid at equilibrium = 0.0262 mol [1]

(e) Hence, calculate the amounts of all the other components in the mixture at equilibrium.

	CH_3OH	+ CH_3COOH	$\rightleftharpoons$	$CH_3CO_2CH_3$	+ H_2O
Initial amt/mol	0.0938	0.0500		0	0.333
Change/ mol	– 0.0238	– 0.0238		+0.0238	+0.0238
Eqm amt/ mol	0.0700	0.0262		0.0238	0.357

1m for each eqm amount

No need for ICE table

equilibrium amount of methanol = 0.0700 mol

equilibrium amount of methyl ethanoate = 0.0238 mol

equilibrium amount of water = 0.357 mol [3]

[Total: 15]

Qualitative Analysis Notes
[ppt. = precipitate]

(a) Reactions of aqueous cations

cation	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt., turning brown on contact with air insoluble in excess	green ppt., turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt., rapidly turning brown on contact with air insoluble in excess	off-white ppt., rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

(b) Reactions of anions

anion	***reaction***
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives pale cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq))
nitrate, NO_3^-(aq)	NH_3 liberated on heating with OH^-(aq) and A*l* foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and A*l* foil; NO liberated by dilute acids (colourless NO ⟶ (pale) brown NO_2 in air)
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids)
sulfite, SO_3^{2-}(aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in dilute strong acids)

(c) Tests for gases

gas	***test and test result***
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	"pops" with lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns aqueous acidified potassium manganate(VII) from purple to colourless

(d) Colour of halogens

halogen	***colour of element***	***colour in aqueous solution***	***colour in hexane***
chlorine, Cl_2	greenish yellow gas	pale yellow	pale yellow
bromine, Br_2	reddish brown gas / liquid	orange	orange-red
iodine, I_2	black solid / purple gas	brown	purple